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Community structure of woody plants on islands along a bioclimatic gradient

Paulo A.V. Borges [1*], Pedro Cardoso [1,2*], Simone Fattorini [3*], François Rigal [1,4], Thomas J. Matthews [1,5,6], Letizia Di Biase [7], Isabel R. Amorim [1], Margarita Florencio [1,8,9], Luis Borda-de-Água [10], Carla Rego [1], Fernando Pereira [1], Rui Nunes [1], Rui Carvalho [1], Maria Teresa Ferreira [1], Heriberto López [11], Antonio J. Pérez Delgado [11,12], Rüdiger Otto [13], Silvia Fernández Lugo [13], Lea de Nascimento [13], Juli Caujapé-Castells [14], Juliane Casquet [15], 6 D P X H O ' D Q L D O [16], Jacques Fournel [17], Anne-Marie Sadeyen [17], Rui B. Elias [1], José María Fernández-Palacios [13], Pedro Oromí [12], Christophe Thébaud [15], Dominique Strasberg [17], Brent C. Emerson [11,18]

*These authors contributed equally to this paper

1 [illegible] and Environmental Changes Azorean Biodiversity Group and Universidade dos Açores, Ru Capitão João d'Ávila, São Pedr 9700-042 Angra do Heroísmo Terceira, Açores, Portugal.

2 Finnish Museum of Natural History University of Helsinki, P.O.Bo [illegible] 00014 Helsinki, Finland

3 Department of Life, Health & Environmental Sciences, Universit of L'Aquila, 67100 L'Aquila, Italy

4 CNRS-Université de Pau et des Pa [illegible] pour l'Environnement et les Materiaux, MIRA, Environment and Microbiology Team, UMR 5254, BP 1155, 64013 Pau Cede France.

Abstract. Understanding patterns of community structure and the causes for their variation can be furthered by comparative biogeographic analyses of island biotas. We used woody plant data at the local scale to investigate variations in species rarity, alpha, beta, and gamma diversity within and between three islands from the oceanic archipelagoes of Azores, Canaries and Mascarene. We used standardized protocols to sample ten 50 m × 50 m forest plots in each of the three islands with contrasting climate and regional species pools: Terceira (Azores), Tenerife (Canaries), and Reunion (Mascarene Islands). Occupancy frequency distributions and species abundance distributions were used to investigate rarity. The partitioning of beta diversity in a distance-decay framework was used to test for spatial patterns of community composition. Rarity was much more pronounced in the highly diverse islands of Tenerife and Reunion than in the regionally poorer island of Terceira. The number of species rose faster with increasing sample area in both Tenerife and Reunion. The slope of the species rank abundance curve was steeper in Terceira whereas the richer island assemblages approached a lognormal model. Compositional changes according to spatial distance were mostly due to replacement of species in Terceira and Reunion. Our results point to important differences in the community structure of Terceira, which is the less diverse and temperate region in comparison to Tenerife and Reunion which are highly diverse.

Key words: Beta diversity partition, distance-decay, islands, rarity, species abundance distribution (SAD), species area relationship (SAR)

5 GEES (School of Geography, Earth [illegible] The University of Birmingham, Birmingham B15 2TT, UK

[illegible] Research, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK

7 Via Dante Alighieri 60, 00071, Pomezia, Italy

8 Departamento de Ecologia, [illegible] Universidade Federal de Goiás, Avenida Esperança, s/n, Câmpus Samambaia, CEP 74690-900, Goiânia, Goiás, Brazil.

9 Department of Life Sciences, University of Alcalá, 28805 Alcalá de Henares, Madrid, Spain

10 REFER Biodiversity Chair, [illegible] em Biodiversidade e Recursos [illegible] Campus Agrário de Vairão, 4485-661 Vairão, Portugal.

11 Island Ecology and Evolution Research Group, IPNA-CSIC, C/ [illegible] 38206 La Laguna, Tenerife, Canary Islands, Spain.

12 Dept. of Animal Biology and Edaphology and Geology, University

} (> > P µ ∀ h > ∀ ô Ù ì ò > Laguna, Tenerife, Canary Islands, Spain.

13 Island Ecology and Biogeography ' Œ } µ / ‰ • X Ÿ š µ ∀ š } À Œ •] š Œ] } Enfermedades Tropicales y Salud Pública de Canarias, University of > > P µ ∀ h > ∀ ô Ù ì ò > > P µ v U Tenerife, Canary Islands, Spain.

14 Jardín Botánico Canario “Viera y Clavijo” - Unidad Asociada CSIC, Cabildo de Gran Canaria. Camino al Palmeral 15, 35017 Las Palmas ' Œ v v Œ] ~ ^ ‰] v • X

í ñ > } Œ š À] Œ µ Ÿ } v À Œ •] š Biologique, UMR 5174 CNRS-Université Paul Sabatier-IRD, 118 route de Narbonne, 31062 Toulouse Cedex 9, France.

16 Conservatoire d’espaces naturels de Midi-Pyrénées, 75 Voie du Toec, BP 57611, F-31076 Toulouse cedex 3, France

17 UMR PVBMT, Université de La Reunion, 15 avenue René Cassin 97744 Saint Denis Cedex 9, Reunion, France.

18 School of Biological Sciences, University of East Anglia, Norwich Research Park, Norwich NR4 7TJ, UK.

Corresponding author: Paulo A. V. Borges, cE3c – Centre for Ecology, À } o µ Ÿ } v v À] Œ } v u Z v š v P • / Azorean Biodiversity Group and Universidade dos Açores - Faculty of Agriculture and Environment, Rua Capitão João d’Ávila, São Pedro, 9700-042 Angra do Heroísmo, Terceira, Azores, Portugal. Ph: +351.295.402200. Paul A. V. Borges: © ‰ W l l orcid.org/0000-0002-8448-7623

Email:paulo.av.borges@uac.pt

Introduction

For a given taxonomic group, alpha diversity (i.e., š Z o } • d ‰] Œ •] Z v • š • U] À Œ •] š X Ç Z U • ‰ Ÿ š µ Œ v] ∀ ‰ Œ] } • u ‰ } •] Ÿ w • P U u u] À Œ •] š X Ç Z } À Œ] ∀ o Œ • š Z Ç Z Œ P] } v o • Œ] + Œ v o š U] š v š Œ Œ o ‰ š (• ‰ Ÿ À Œ] Ÿ v } ‰] v µ u Œ v • } u ‰ } •] Ÿ } v P v Œ î ì í ð • d Z • u • µ Œ } (•] À Œ Z] š Á Ç À Œ } v U š } v •]] Œ + Œ • v ‰ } š (• ‰] Œ • Œ / š • Ç L X v š Z • š Z Œ • Œ } Z v o Œ } • µ } v š Z • ‰ Ÿ] • š Œ] µ (Ÿ ‰ v] ~ ‰ Œ • v r • š v • µ š } š Z] 8 µ d š Ç š] v] • v š P v Œ] ì µ v v š ~ ' • š } õ õ ð / • v X š U µ Ç š Z Œ o Ÿ } v • between alpha, beta, and gamma diversity with species µ v v] • } v o Œ v Œ o Ç] À] © v P Ÿ } ~ v X P X , Œ š š o î X í ï õ µ µ ô ò ï ü Y µ š o î X í ñ • X š Z] • } v š Æ µ š U } š Z } ‰ o Ÿ] • ô o Ÿ] w •] u ‰ o] . G } Œ v • (µ v } • U v]] • o v } + • Œ Z ‰ } • •] o of performing studies that simultaneously account for À Œ] Ÿ Y v • À Œ • ‰ } š (• } u u µ v] • š š Œ Œ µ š µ v u o š Ç Z Œ o Ÿ } v • Z À ‰ Œ Œ] š š Z • ‰ Ÿ] • š Œ] µ Ÿ } v µ v v o U ‰ Z š U Y P u u diversity.

t] š Z (Á Æ ‰ Ÿ } ‰ • U] • • • u o P v • temperate regions are less diverse than assemblages] v } u ‰ Œ š Œ } ‰ Œ P o] } v • Œ } Ã í ñ • } š Z] v š Œ µ (• o } Œ] Z v ~ • o ‰] À Œ •] š Ç š] À Œ •] Y s u Ç o X î ì í ñ • X] + Œ v] v • • ‰] community structure between species-poor temperate regions and species-rich tropical regions can arise from u µ o Ÿ ‰ Œ } •] • v • d u µ ô ò ï Ã Á • Z] P Z] v } ( ] v š Œ • ‰] v š] . Œ Y v } v • ‰] Y Œ } v š ~ µ • š ^ Z o µ î s í Œ • Œ Œ v œ š] u š] • š } Œ Ç } (P o] Ç o o] ~ v P X P X Á U ô õ õ • X } u u } v } • Œ À Ÿ • š Z š Æ } v } u]] À Œ •] v š Œ } ‰] systems is characterized by an excessive number of geographically restricted and low abundant species, a ‰ © Œ ∀ µ u v š š o • (š Œ Œ ~ ; µ î ò ï V ^ š P š o X î ì í ï • X / v š Z • š µ Á U v À • Ÿ P š Z ‰ © Œ (À • Œ] Ÿ } • v] š Œ] v] À Œ •] v] š Œ Œ] Œ Œ } Ç ‰ o v š u µ v] Ÿ • š Z] • o v ~ d Œ v Œ Z µ v] } w • u] Æ š µ (Œ Á] š Z] w š Á š v Z Œ] • Ÿ v } š v] • o v ~ • š Z ‰ Œ] • Ÿ v Z] • š] Œ } P Œ ‰ Ç u v Ç • } o • š u ‰ Œ • œ š ∀ (d Œ ~] Œ } Œ ~ • š Z • µ š Œ } ‰] • o ∀ (d v Œ ~] (v Œ] v • š Z ~ ï š Œ } ‰] • o v } (Z µ v] } v D • Œ d Z • • š Z Œ] • o v • v } v •] Œ Œ ‰ Œ • ∀ (š] • À Œ P v š P Œ ‰ Z]] • « v P Á •] š Z v š Œ • Ÿ ô ∀ u P š d • Œ Œ]] • Œ Ç } µ v P] • o ∀ ï X Ð í • o } v P š ∀ š P Z š o v Œ Ž] ‰ o P } (š Z ì } Œ ~ u Ø Œ X Ð • Á] š o Z } Á Œ] š] š À Œ •] š Ç ~ } Œ P v • } Œ š ì ò õ U Œ] v š Y o î X í î • d v Œ] ( ] • v } o] Œ o ∀ í Ð • o • ‰ Œ { š v } š Z š Œ o v Ÿ Œ Œ Z] ‰ ~ d š Z P) v Œ] Á •] š Z o } v P P Œ } o } P] o Z] • š } Œ Ç Á Œ D • v Z] P Z À Œ • ( ] š o Ç u š o • •] . Ÿ } • v Ð } v š } Ç r o š v o î X í ò •] Z • a high biological diversity and is a biodiversity hotspot in the Macaronesian region (Fernández-Palacios and (Z] © l î Œ ì ô • & X] v o Z o Ç U] } ~ v ì X Ð • o } v P • š } š Z D • Œ / • o v ~ u Á Œ D • U š Œ } ‰] o Z ‰ archipelago located in the southwestern Indian Ocean known for its high level of diversity (Thébaud et al. ì ì õ U] Œ š o î X í ì • d Z • š Z Œ] • o v Á • Œ sampled using the same methods, giving us the unique } ‰ ‰ } Œ š (µ] w] Á š Ç Ÿ P Á Ÿ Z v P š Z š Z Œ } • Œ À ‰ © Œ v v) • u u µ v] • š š Œ Œ µ š Œ Œ Œ v •] • š Á v] š Z P š o Ç ‰ o © Œ (v Á • Œ] Ÿ v) ‰ o v] À Œ •] Y š Z Œ U ~ í š Z • š ‰] • • u o P v • Œ] v] À Œ (Œ š } Ç Œ temperate to tropical regions (Brown 2014, Xu et al. (ì í ñ • v ~ î š Z š Z] v G µ v] (Œ Œ P ‰] } v taxonomic diversity increases from temperate to tropical Œ P] } v µ î ò ó ï U š P š o î X í ï • d X } Œ • • š Z • < µ • Ÿ } v Á • U v o Ç • v } u ‰ Œ À Œ o u ‰ } Œ š • v Œ] ‰ (š } Œ u µ v] • š š Œ Œ µ š ú š Œ Z W } µ ‰ v Ç r (Œ] •] š Œ Z] Ç u Ÿ K } & • • v • ~ î š Z • ‰] • r µ v] v š Œ] µ Ÿ } v ø }] v À • Ÿ P š š Á) } Œ Ÿ (Œ Œ ~] š X Ç V X U v v µ v v • V ~ ï š Z v • š • ‰] • r Œ Œ o Ÿ } v •] Z v] Á ‰ • Ÿ P š š Z • ‰ Ÿ • o o]] v (P Œ Œ] v š Ç ô ô • Z ‰ Œ Ÿ Ÿ } v] v P of beta diversity using a distance-decay framework to š • š (} Œ • ‰ Ÿ o ‰ © Œ v •] v } u u µ v] š

Methods

Field data collection

E Ÿ À Á U š U v o Œ P µ v o Ç • š µ Œ } Œ • Œ š • across the three study islands were selected. Study] • o ∀ (d v Œ ~] (v Œ] v • š Z Ø ~ ï š Œ } ‰] • o ∀ (d v Œ ~] (v Œ] v • š Z Ø

platycodon, Ilex canariensis, Laurus novocanariensis, Morella faya, Prunus lusitanica, and Viburnum rigidum, Erica arborea, Erica scoparia, Ilex canariensis, Myrica

of beta diversity in Reunion, which can impact on the value of the slope, led us to restrict the analyses for Reunion to only four plots located within a 12 km range, similar to the range covered by the 10 plots in Terceira and Tenerife. Thus, when we compared the slopes between the three islands, we avoided between plots in Reunion. The ten plots in Reunion should be stronger in the islands with more species (distances between individuals collected in the same observed distances were compared with 999 null distributed among the ten studied sites on each island. the observed average distance was below the 0.025 and abundance data.

regressed against the geographical distance between distance due to either a decrease in environmental similarity or by limits to dispersal and niche width differences among species (Nekola and White that beta diversity measures should be correlated diversity with interplot geographical distances. diversity and geographical distances was tested with Mantel tests using the R package vegan (Oksanen et and distance was tested using the R Package simba

Results

Alpha, beta and gamma diversity patterns

93 woody plant species were sampled across thirty Tenerife had very similar values of average alpha diversity the other two islands. Beta diversity in Reunion was than Tenerife. The density of woody plants in Terceira gamma diversity in Terceira were the lowest of the

Table 1. Diversity metrics for woody vascular plants is the accumulated total number of species in the ten plots. Alpha is the mean number of species in the ten plots. Max and Min alpha is the maximum and minimum number of species found in the ten plots, respectively. N is the number of individuals.

	Terceira	Tenerife	Reunion
N	2186	715	1497
Gamma	11	17	67
Alpha	7.3	7.4	25.6
Beta	0.51	1.16	1.61
Max alpha	9	9	33
Min alpha	5	5	16

Rarity

of wood plant rarity. In Terceira, only 18% of woody plant species occur in one plot whilst 45% occur in all ten plots (Tokeshi test followed, with 25% of the plant species occurring in only one plot and 3% occurring in all 10 plots (Tokeshi test

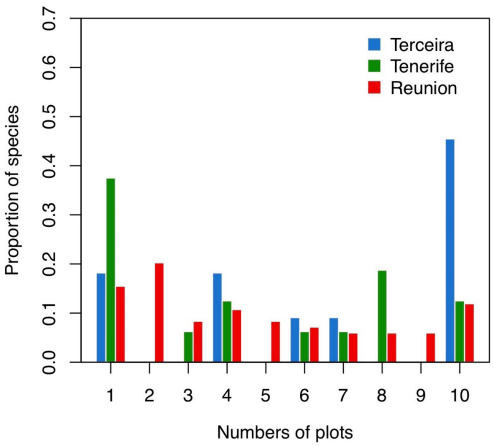

Figure 1.

Table 2. AIC values for the three SAD models (logseries, Poisson lognormal-PLN, and Zipf-Mandelbrot). The best model is highlighted in bold. Gambin's alpha parameter

	Terceira	Tenerife	Reunion
Logseries	67.69	88.59	317.64
PLN	64.54	76	277.66
Gambin	65.46	75.31	274.36
Alpha	13.41	6.67	2.24

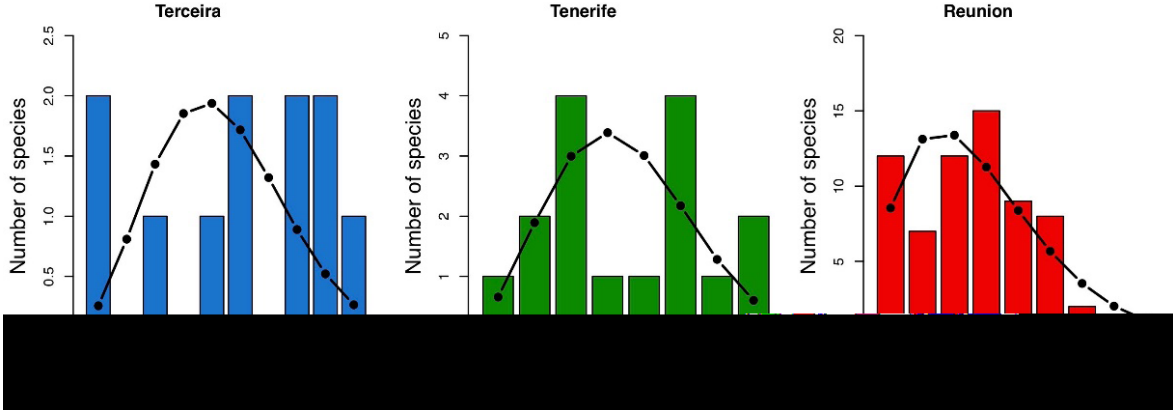

Figure 2. Abundance histograms for the three islands. The following binning system was used: 0 corresponds to the number of species with 1 individual per species, bin 1 corresponds to the number of species with 2-3 individuals per species, bin 2 corresponds to the number of species

Species Area Relationships

The analyses of nested SARs confirmed the rapidly as sampling area increases in the two islands with the highest species richness (higher compared to the species poor and temperate island comparisons

Figure 3. Geometric series rank-abundance plots for woody number of individuals as in the island with a lower overall values: Terceira , Tenerife , Reunion .

Figure 4.

